Room-Temperature Reversible Spin Hall Effect

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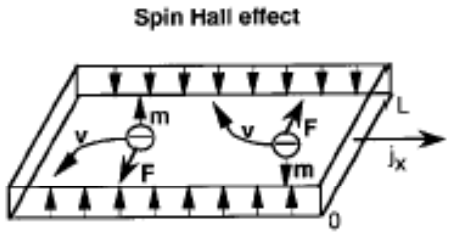
Overview

First detection of Spin Hall effect at room temperature in metal

- Direct and Inverse Spin Hall effect
- Device: Materials and Geometry
- Results and Implications

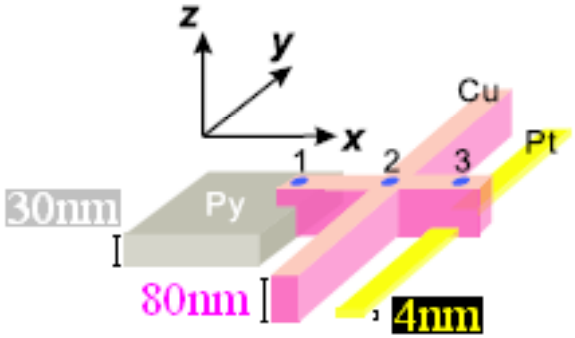
SHE and ISHE

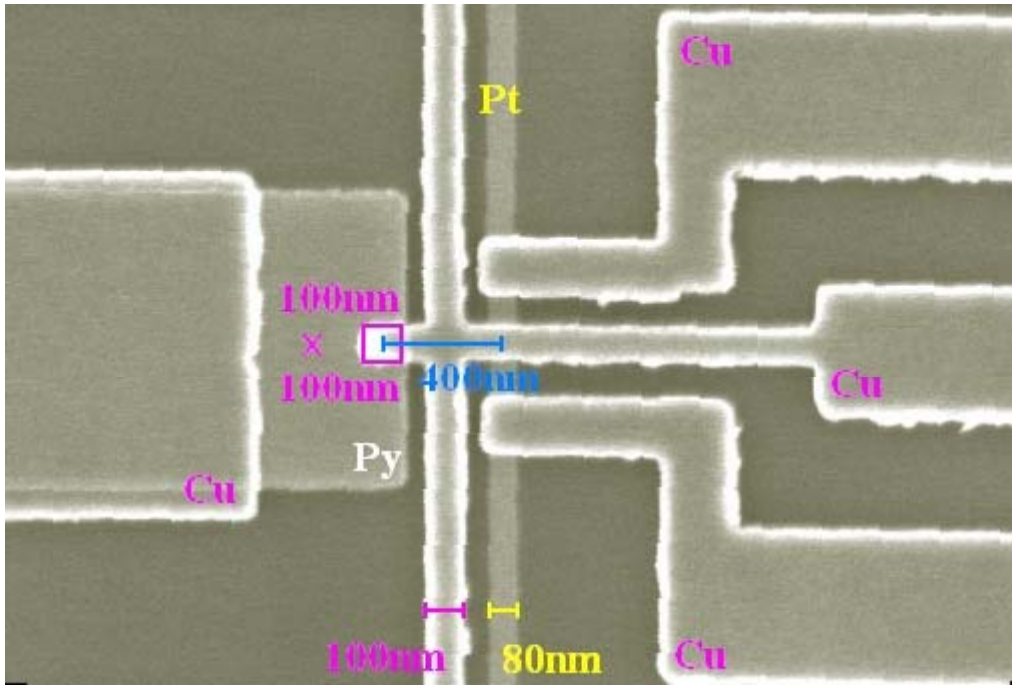
- Charge current results in perpendicular spin current
  - Intrinsic: Rashba coupling; results in a torque on the spin itself
  - Extrinsic: Spin-orbit dependent scattering from impurities



- Spin-polarized current results in perpendicular charge current due to anomalous effect (also from spin-orbit coupling)

Device

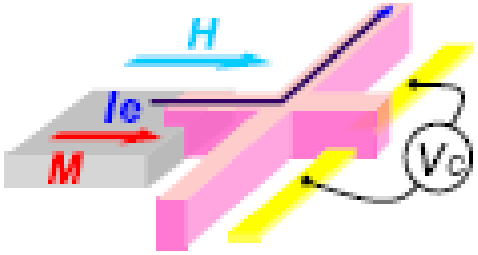


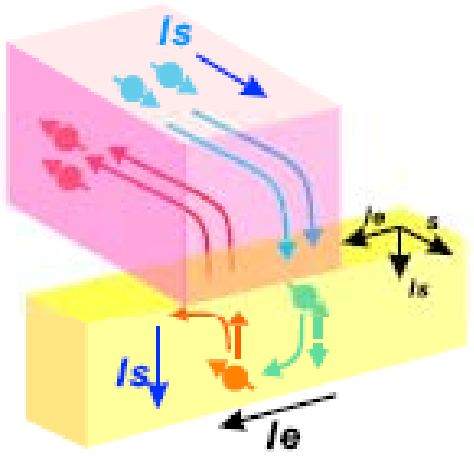


- Copper has a spin diffusion length of 500nm at room temperature.
- Platinum used for strong spin-orbit coupling.

  It has a very short spin diffusion length of 3nm at room temperature.

Inverse SHE

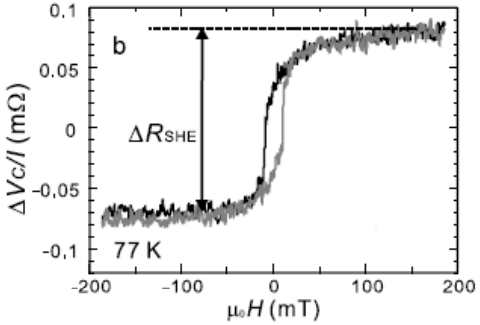


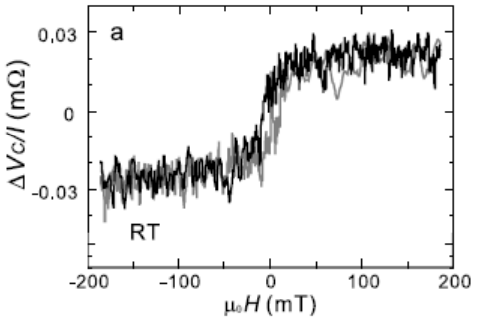


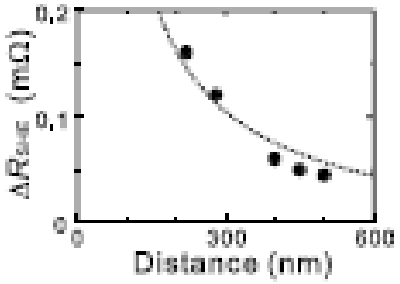
- Polarized current injected from Py and drained through one of the Cu arms
- Spin accumulation and diffusion
- Dependence on direction of Magnetization and hysteresis present
- Py to Pt Distance dependence (@ RT)

$$\Delta R_{SHE} \propto \{\sinh[(d/\lambda_{Cu})]\}^{-1}$$

(from SH conductivity equation)

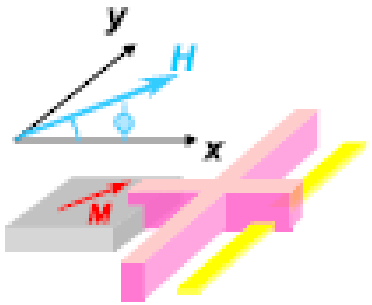




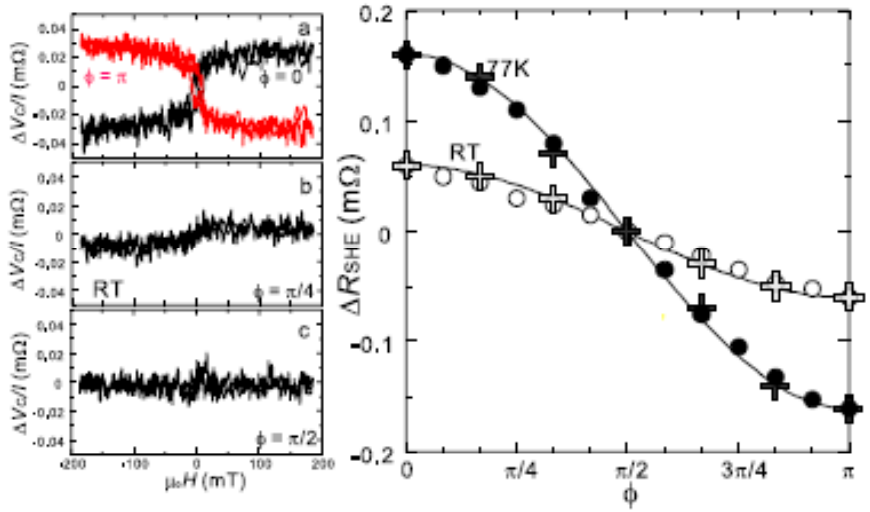


Angle Dependence

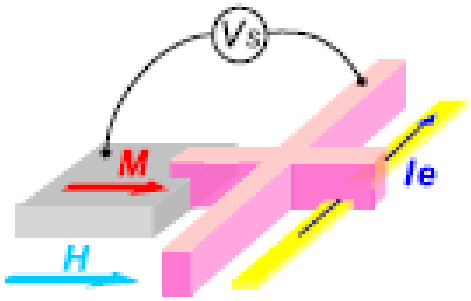
- Sweep with different angles of in plane field

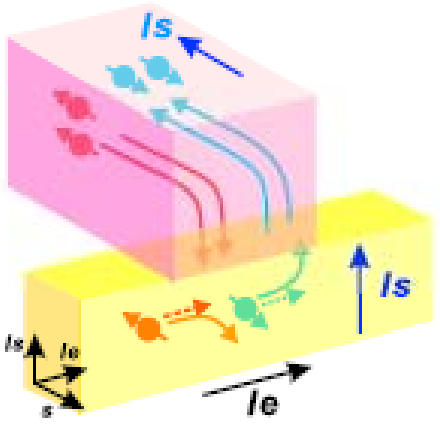


- Cosine dependence of ΔR_{SHE} as expected from $\overrightarrow{I_C} \propto \vec{S} \times \overrightarrow{I_S}$

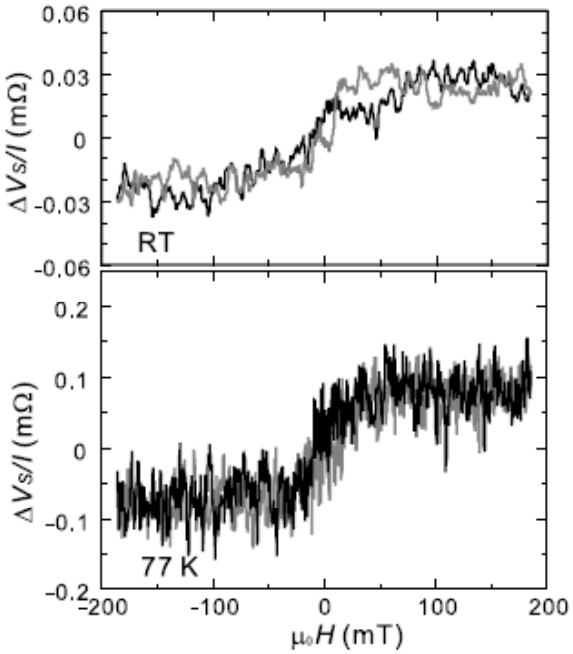


Direct SHE





- Voltage measured across Cu/Py interface
- Due to GMR; spins aligned with Py's magnetic moment pass through the interface more easily. This results in a potential difference as oppositely aligned spins are moving in opposite directions
- Found same cosine angle dependence



In Agreement

- Found that spin-current induced conductivity is equal to the charge-current induced conductivity as expected in the Onsager reciprocal relation.
- Also verified spin-orbit parameter (which is depended on the SH conductivity) to be in good agreement with previous results
- Allows the use of normal metal to be used as polarized current creator at room temperature without the use of magnets.